

## **SPECIFICATION**

To All Whom It May Concern:

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Be It Known That I, Gary A. Landolt, a citizen of the United States, resident of the City of Wood River, State of Illinois, whose full post office address is 355 Hillview Drive, Wood River, Illinois 62095, have invented certain new and useful improvements in

### **APPARATUS FOR RATING A TORSION BAR**

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## CROSS REFERENCE TO RELATED APPLICATIONS

### STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

5           Not Applicable

### BACKGROUND OF THE INVENTION

          This invention relates in general to measuring devices and more particularly to an apparatus for determining the rating of a torsion bar.

          The handling characteristics of race cars depend to a measure on the stiffness of the  
10   suspension systems for such cars. Moreover, track conditions and configurations vary, each requiring a suspension system tailored to it. For example, dirt track races always proceed counterclockwise around an oval track, so all of the turns are left turns. Drivers prefer to stiffen suspensions at the left front and right rear wheels of their cars. This improves both control and traction.

15           The suspension system of a typical sprint car has four torsion bars – one for each wheel. The bars extend transversely across the vehicle, with two ahead of the front axle and two behind the rear axle. While the bars are traditionally classified by size, many drives prefer to classify them by rate, and one rate that has found acceptance is the amount of force required to deflect a torque arm at one end of a bar one inch. . Thus, a bar rated at  
20   235 lbs. would be stiffer than one rated at 197 lbs. Rates may vary among bars of the same size. Each torsion bar exerts a downwardly directed force on the axle near the wheel with which it is identified and an upwardly directed force on the frame of the car at the corner where the wheel is located, thus suspending much of the weight of the vehicle. The bars

are accessible at the ends of the car and require little effort to remove and replace. Often a driver will replace an entire set of bars with a new set more suited for the conditions of a forthcoming race. However, before a driver replaces any torsion bar, he should know how it will react in the race car, and this depends on the spring rate for the bar.

5           Testing devices exist for comparing torsion bars of a set or in collection at a driver's disposal. Indeed, manufacturers of torsion bars sometimes apply ratings to them, but the ratings may not correlate to the ratings used or acquired elsewhere, and furthermore may not be accurate. In any event, the testing devices used by manufacturers are much too large to be used by individual drivers, particularly at the tracks where they race. Another  
10   testing device exists which is suitable for use in a shop, but is not easily transported to a track, and furthermore is expensive. Still another testing device is available which is small enough to transport to a track, but does not rate bars according to any recognized standard. Moreover, the devices currently available twist the bars in only one direction of rotation, but the rates of some bars vary, being of a magnitude in one direction of rotation that is different  
15   than the magnitude in the opposite direction.

#### BRIEF SUMMARY OF THE INVENTION

          The present invention resides in an apparatus for determining the spring rate of a torsion bar. The apparatus includes a frame having two channels each of which is configured to receive a torsion bar. At one end of the frame is force applicator and at the  
20   other end is a measuring device. One torque arm extends between the force applicator and the channel in which a torsion bar is received and another torque arm extends between that channel and the measuring device. The invention also resides in an apparatus for determining the spring rate, with the apparatus including a frame and having a channel

configured to receive a torsion bar and a force applicator at one end of the frame. A torque arm extends between the end of the channel and the force applicator for applying a torque to a torsion bar in the channel when a drive element of the force applicator moves from a retracted position to extended positions. The drive element has a depression in which a transfer element on the torque arm is initially seated, and thereafter secured so that when the drive element is extended, the moment arm formed by the torque arm remains constant.

#### BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Fig. 1 is a fragmentary perspective view of a front corner of a sprint car, the torsion bars of which are rated with the apparatus of the present invention;

Fig. 2 is an exploded perspective view of the rating apparatus of the present invention and further illustrating one of the torsion bars rated with the apparatus;

Fig. 3 is a perspective view of the rating apparatus with a torsion bar extended through it, for rating;

Fig. 4 is a fragmentary end elevational view of the rating apparatus taken along line 4-4 of Fig. 3;

Fig. 5 is a perspective view of the pneumatic cylinder for the rating apparatus;

Fig. 6 is a fragmentary plan view of the rating apparatus taken along line 6-6 of Fig. 4;

Fig. 7 is a fragmentary end elevational view of the rating apparatus taken along line 7-7 of Fig. 3;

Fig. 8 is an end elevational view similar to Fig. 4, but showing the piston of the pneumatic cylinder extended to its fullest extent;

Fig. 9 is a perspective view of a set key forming part of the present invention; and

Fig. 10 is an end elevational view similar to Figs. 4 and 7, but showing the set key fitted to the piston of the pneumatic cylinder to extend the piston a prescribed distance.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

## 5 DETAILED DESCRIPTION OF INVENTION

Referring now to the drawings, an apparatus A (Figs. 2 & 3) measures with considerable accuracy the spring rate of a torsion bar B which may be one of several bars B forming part of the suspension system of an automotive vehicle C (Fig. 1), such as dirt track sprint car. The apparatus A enables one to determine and compare the spring rates of all  
10 torsion bars B on the vehicle C, so that the vehicle C has a set of bars B that provide for optimum traction and control under the driving conditions anticipated.

Considering the bar B first, it has (Fig. 2) a spline 2 at each end and a cylindrical active region 4 located between the two splines 2. The two splines 2 and the active region 4 have a common center, it being an axis X. Typically, all the bars B in a set of bars B for the  
15 vehicle C will have splines 2 of the same diameter, but the diameters of the intervening active regions 4 will vary. Even so, the diameters of the active regions 4 will never exceed the diameter of the splines 2. The variance in the diameters of the active regions 4 imparts different spring rates to the bars B, those of greater diameter generally having higher spring rates than those of lesser diameter. One standard used to compare spring rates is the  
20 amount of force required to deflect the remote end of a 12-inch torque arm on the bar B one inch. For example, if 235 lbs applied twelve inches from the axis X of the bar B deflects the 12-inch torque arm one inch, the bar B has a rating of 235 lbs. – or more precisely 235 ft-lbs./in.

Basically, the vehicle C, when in the form of a sprint car, has (Fig. 1) a frame 10 located over solid axles 12 with wheels 14 at the ends of the axles 12. The frame 10 at each of its ends has a pair of tubes 16 which are located beyond the axle 12 at that end. Each tube 16 contains a torsion bar B, with the splines 2 on the bar B being located beyond the ends of the tube 16. Clamped around one spline 2 is a stop 18 which bears against the frame 10 and resists torque that is applied at the other end through a torque arm 20 which is clamped around the spline 2 at that other end. That torque arm 20 is connected to or bears against the nearby axle 12 adjacent to the wheel 14 to which the bar B transfers its portion of the suspended weight of the vehicle C.

Turning now to the testing apparatus A, it includes (Figs. 2 & 3) a base 30 which is capable of receiving the torsion bar B such that the bar B can be twisted between its ends and the torque – or more accurately, the force component of the torque – required to twist it measured. The apparatus A also includes a long torque arm 32 through which torque is applied to the bar B that is received in the base 30 and a short torque arm 34 through which the applied torque is resisted. In addition, the apparatus A has a set key 36 which establishes a known deflection at the end of the long torque arm 32 and compensating keys 38 which compensate for variances between the length of the long arm 32 and the effective length of the torque arms 20 on the vehicle C. Finally, the apparatus A includes a calibration bar 40 which is similar to the bar B, but has a known spring rate determined independently of the apparatus A.

The base 30 includes (Fig. 2) a frame 44 having a head end 46 and a tail end 48. Along the sides of the frame 44 are tubular members 50 which neck inwardly between their ends 46 and 48, so that they flare outwardly toward the two ends 46 and 48. The two side

members 50 are connected by upper plates 52 and lower plates 54 which are welded to the members 50, so that the members 50 together with the plates 52 and 54 impart considerable rigidity to the frame 44. The spacing between the tubular side members 50 is greatest at the head end 46, and here even more rigidity is imparted to the frame 44 by ribs 56 which fit between the upper and lower plates 52 and 54 and are welded to them. More ribs 56 fit between the upper and lower plates 52 and 54 at the tail end 48. Immediately inwardly from the ends of each side member 50, the space between the upper and lower plates 52 and 54 is occupied by a bushing 60 which is attached firmly to the plates 52 and 54. Each bushing 60 has a bore large enough to loosely receive the spline 2 on a torsion bar B. The bushings 60 are arranged in pairs, with the bushings 60 of each pair being at opposite corners of the frame 44. The bushings 60 of one pair align along an axis Y and the bushings 60 of the other pair align along an axis Z. The axes Y and Z intersect between the head end 46 and tail end 48 of the frame 44 and thus define a plane.

The ribs 56 at the head end 46 of the frame 44 create a cradle which receives a force applicator which may take the form of an adjustable pneumatic cylinder 64. It has (Fig. 8) a barrel 66 which is attached firmly to the upper plate 52 of the frame 44 and rests on the bottom plate 54 and a piston 68 which rises out of the barrel 66 when pressurized air is admitted to the barrel 66 behind it. The piston 68 constitutes a drive element through which the cylinder 64 exerts a force on the long torque arm 32. The axis of the cylinder 64 lies perpendicular to the plane formed by the intersecting axes Y and Z, and the piston 68 moves along the cylinder axis between a retracted position and an extended position. In this regard, the piston 68 has a maximum extension of typically  $1 \frac{1}{4}$  in., but when rotated to a prescribed position, it will extend a lesser distance, in this instance 1 in. In that sense the

cylinder 64 is adjustable. The piston 68 contains an annular groove 70 which opens out of its cylindrical side surface slightly below its upper end. It also has a top surface 72 which contains a depression 74 (Fig. 5) in its very center. Otherwise the top surface 72 is flat and perpendicular to the axis of the cylinder 64. The force exerted by the piston 68 is transferred  
5 through the top surface 72 which thus functions as a drive surface.

The barrel 66 of the pneumatic cylinder 64 is connected to an air line 76 (Fig. 2) through which pressurized air is admitted to it below the piston 68. The air line 76 originates at a quick-connect coupling 78 on the upper plate 52 of the frame 44, it being configured to connect with a source of pressurized air such as an air hose. The air line 76 passes through  
10 a manually-operated valve 80 also mounted on the top plate 52. When the valve 80 is closed, the barrel 66 of the pneumatic cylinder 64 is vented and the piston 68 assumes its retracted position within the barrel 66. However, when the valve 80 is opened, pressurized air flows through the line 76 to the barrel 66 of the cylinder 64 and drives the piston 68 to an extended position.

15 The ribs 56 at the tail end 48 of the frame 44 form another cradle which receives a measuring unit 82 (Fig. 7) including a barrel 84 which is fixed firmly to the frame 44 and a sensing element 86 which is exposed at the top of the barrel 84. When a downwardly directed force is applied to sensing element 86, the pressure of the hydraulic fluid in the barrel 84 increases. That pressure is reflected on a display 90 (Fig. 3) which is mounted on  
20 the frame 44 adjacent to the barrel 84 and is exposed through the upper plate 52 of the frame 44. The hydraulic fluid is for all intents and purposes incompressible, so the sensing element 86 does not move. While the display 90 actually reflects the pressure in the device, the number it registers represents an actual force in pounds that is correlated to the force



exerted by the piston 68 of the cylinder 64 and transferred to the measuring unit 82 through the torsion bar B and the torque arms 32 and 34 on its ends.

The long torque arm 32 at one end has (Fig. 4) an internal spline 94 and a slit 96 leading away from the spline 94 to the end surface of the arm 32, so that the size of the spline 94 may be varied, although minutely. To effect this variance, the end of the torque arm 32 is fitted with a clamp screw 98 which passes through the slit 96. When the screw 98 is turned down, the spline 94 contracts. The spline 94, when expanded, which is the configuration that it naturally assumes, fits over the external spline 2 at either end of the torsion bar B. Thereupon, the clamp screw 98 is tightened to contract the spline 94 and clamp the splined end of the arm 32 snugly around the external spline 2 on the bar B. At its other end, the long torque arm 32 has a cylindrical bore 100 with a slit 102 leading away from it to the end surface of the arm 32. Here another clamp screw 104 extends through the arm 32 and passes through the slit 102. When turned down, the screw 104 contracts the bore 100 against the natural bias of the metal from which the arm 32 is made. The long arm 32 also has elongated openings 106 (Fig. 2) that lead into the bore 100 from the top and bottom of the arm 32 with their major axes extending longitudinally in the arm 32. The cylindrical bore 100, receives a cylindrical swivel 108 which fits loosely in the bore 100 when the clamp screw 104 is backed off, so that the swivel 108 will rotate, but is fixed tightly in the arm 32 when the screw 104 is tightened.

The swivel 108 supports an adjusting screw 110 (Fig. 8) which threads into it. Indeed, the screw 110 passes completely through the swivel 108 and also through the elongated openings 106 (Fig. 2) so that it projects both above and below the openings 106. At its upper end the screw 110 has a thumb wheel. Its lower end aligns with the top surface

72 on the piston 68 and is beveled, thus providing a tapered end 112 which is small enough to fit into the depression 74 in the top surface 72. Since the openings 106 that lead away from the bore 100 are elongated, the adjusting screw 110 can move to and fro in them. This affords a limited amount of rotation for the swivel 108 in the bore 100, assuming that the  
5 clamp screw 104 is backed off.

When the tapered end 112 of the adjusting screw 110 is in the depression 74 (Fig. 4) in the top surface 72 of the piston 68 and the piston 68 is retracted, the distance between the axis Y or Z of either pair of bushings 60 and the centerline of the screw 110 is a known distance, such as 12 in. Once the clamp screw 104 is tightened, that distance is maintained,  
10 even though the tapered end 112 of the clamp screw 104 may climb out of the depression 74 and onto the flat portion of the surface 72 surrounding it (Fig. 8). In this regard, the piston 68, as it extends, does not follow the arc transversed by the tapered end 112 of the screw 110. The small torque arm 34 at its one end has (Fig. 7) an internal spline 116 and a slit 118 leading from the spline 116 to the end surface of the arm 34. The spline 116 is  
15 contracted by a clamp screw 120 which passes through the end of the arm 34 including the slit 118 at that end. With the clamp screw 120 backed off, the spline 116 on the short arm 34 fits easily over and engages the spline 2 on either end of the torsion bar B. When the clamp screw 120 is turned down, it contracts the spline 116 and secures the short arm 34 firmly on the spline 2 of the torsion bar B. At its opposite end the short torque arm 34 has a  
20 nib 122 which bears against the sensing element 86 for the measuring unit 82. The distance between axis X of the bar B to which the arm 34 is fitted and the end of the nib 122 remains constant and is known.

Each of the keys 36 and 38 has (Figs 2 & 9) a U-shaped end 126 and a lip 128, which extends along the end 126 where it is directed inwardly along the margin of the end 126. The U-shaped end 126 is configured to fit around the piston 68 of the cylinder 64 with the lip 128 projected into the annular groove 70 in the piston 68, when, of course, the piston 5 68 is extended from the barrel 66. When the end 126 of any key 36 or 38 is so fitted to the extended piston 68 and the piston 68 is thereafter moved toward its retracted position, the key 36 or 38 limits the distance that the piston 68 can retract. Actually, each key 36 and 38, when fitted to the piston 68, which is then retracted as far as it can go, leaves the piston 68 extended a known distance. For example the set key 36, which has only one U-shaped end 10 126, leaves the piston 68 extended slightly less than one inch, but that translates into a one inch displacement for the tapered end 112 on the adjusting screw 110, given the fact that the tapered end 112 jumps out of the depression 74 and onto the surrounding flat portion of the top surface 72 during this displacement (Fig. 10). Each of the compensating keys 38 have two U-shaped ends 126 and lips 128, and they hold the piston 68 less extended.

15 In use, the testing apparatus A determines the spring rate of the torsion bars B used on an automotive vehicle C, such as a sprint car. But before any bar B undergoes evaluation in the apparatus A, the apparatus A, particularly its measuring unit 82, needs to be calibrated. To this end, the calibration bar 40, which has a known spring rate determined independently of the apparatus A, is inserted (Fig. 2) through the two bushings 60 along the 20 axis Y or the bushings 60 along the axis Z, whichever will enable the apparatus A to twist the bar 40 in the direction that led to the determination of its spring rate. The calibration bar 40 fits loosely in the bushings 60 with the splines 2 at its ends projecting beyond the bushings 60 and out of the frame 44 (Fig. 3). Its axis X coincides with the axis Y or Z,

whatever may be appropriate. The internal spline 116 in the short torque arm 34 is engaged with that external spline 94 of the calibration bar 40 which projects from the tail end 48 of the frame 44. The clamp screw 120 on the short arm 34 is tightened, thereby clamping the short bar 34 securely to the calibration bar 40. The bar 40 is rotated until the nib 122 at the  
5 opposite end of the bar 40 bears against the sensing element 86 of the measuring unit 82. Thus, one end of the short torque arm 34 is supported on the calibration bar 40, while the other end is supported on the sensing element 86 of the measuring unit 82.

At the head end 46 of the frame 44, the internal spline 94 on the long torque arm 32 is fitted to that spline 2 of the calibration bar 40 which exposed at the head end 46, care  
10 being taken to insure that the tapered end 112 of the adjusting screw 110 locates directly over the piston 68 of the pneumatic cylinder 64 with perhaps an inch of the screw 110 projecting out of the lower elongated opening 106. The clamp screw 98 at the spline 94 is then tightened to secure the long torque arm 32 firmly to the calibration bar 40. Then, with the clamp screw 104 at the other end of the arm 32 backed off, the adjusting screw 110 is  
15 manipulated by rotating the swivel 108 through which it threads and turning it to extend it through the swivel 108 until its tapered end 112 seats in the depression 74 that opens out of the top surface 72 of the piston 68 (Fig. 4). The clamp screw 104 is then tightened to prevent the swivel 108 from rotating.

At this juncture the valve 80 is opened and closed several times. Each time it is  
20 opened, the piston 68 of the pneumatic cylinder 64 rises and rotates the long torque arm 32 about the axis X of the bar 40. The short torque arm 34 resists the rotation, inasmuch as its nib 122 bears against the sensing element 86 on the measuring unit 82, so the bar 40 twists between its splines 2 several times. This seats the mating spline 2, 94, and 116.

Next, with the valve 80 closed, and the clamp screw 104 backed off to releases the swivel 108, the adjusting screw 110 is rotated until the display 90 reads "0". The clamp screw 104 is then tightened to secure the swivel 108 with the tapered end 112 of the adjusting screw 110 in the depression 74 of the piston 68. Thereupon, the valve 80 is  
5 opened to admit pressurized air to the barrel 66 of the pneumatic cylinder 64. The piston 68 rises in the barrel 66 and drives the adjusting screw 110 upwardly about 1 ¼ in. The tapered end 112 of the screw 110 moves in an arc, inasmuch as the arm 32 pivots about the axis X of the calibration bar 40, while the piston 68 translates along the axis of the cylinder 64 which is vertical and perpendicular to the plane defined by the intersecting axes Y and Z.  
10 As a consequence, the tapered end 112 leaves the depression 74 and moves onto the flat surrounding portion of the top surface 72 on the piston 68 (Fig. 8). The short torque arm 34 remains fixed in position, so the calibration bar 40 twists between the two torque arms 32 and 34. The twist, which is well within the elastic limit of the bar 40, exerts a torque on the small arm 34, and that torque translates into a force at the nib 122. The measuring unit 82  
15 registers that force on its display 90.

With the piston 68 of the pneumatic cylinder 64 extended to its fullest extent, which is about 1 ¼ in., the U-shaped end 126 of the set key 36 is fitted over the side of the extended piston 68, care being exercised to insure that the lip 128 on the U-shaped end 126 enters the annular groove 70 on the piston 68. Thereupon, the valve 80 is closed to vent the barrel  
20 66 of the cylinder 64. The torque applied to the long arm 32 drives the piston 68 back into the barrel 66 until the set key 36 bottoms out on the barrel 66 (Fig. 10). This leaves the piston 68 extended essentially one inch, which is the deflection at which the calibration bar 40 was independently rated. It also corresponds to the lesser extended position for the

piston 68, that is the extension when the piston 68 is rotated to the prescribed position. The reading on the display 90 should correspond to the rating of the calibration bar 40. If it does not, the display 90 is reset. For example, if the calibration bar 40 is rated at 265 lbs. for a one-inch deflection on a 12 in. torque arm and the display 90 reads 267 lbs., the measuring  
5 unit 82 is reset so that its display 90 reads 265 lbs.

While the calibration unit 82 actually measures the pressure of the hydraulic fluid in the barrel 84 of the gauge cylinder 82, the length of the torque arms 32 and 34 and the dimensions of the barrel 84 and piston 86 are such that the pressure registered on the display 90 numerically corresponds to the force exerted by the long torque arm 32 on the  
10 extended piston 68 of the pneumatic cylinder 64.

Once the measuring unit 82 is calibrated an actual torsion bar B may be rated. The procedure is basically the same as the one used to produce a reading for the calibration bar 40. Briefly, the bar B is inserted through a pair of bushings 60 that align along the axis Y or the axis Z, depending on the direction it will twist in use. In this regard, a bar B in the  
15 bushing 60 along the axis Y will twist clockwise, whereas a bar B in the bushings 60 along the axis Z will twist counterclockwise. Then the torque arms 32 and 34 are installed on the exposed splines 2 at the ends of the bar B, and the clamp screws 98 and 120 are tightened. So too is the clamp screw 104 for the swivel 108, but only after the tapered end 112 of the adjusting screw 110 seats in the depression 74 of the piston 68. The valve 80 is opened  
20 and closed several times so that the engaged splines 2, 94 and 116 seat. Next the clamp screw 104 is backed off to free the swivel 108, and the adjusting screw 110 is turned until the display registers "0". The clamp screw 104 is now tightened to secure the swivel 108 with the tapered end 112 of the adjusting screw 110 in the depression 74 of the piston 68.

Thereupon, the valve 80 is opened to energize the pneumatic cylinder 64. The piston 68 rises to its fullest extent, whereupon the set key 36 is fitted to the piston 68. The valve 80 is then closed and the piston 68 retracts under the torque exerted by the bar B until restrained by the set key 36. The force registered on the display 90 is noted and recorded against the  
5 bar B. It represents the force exerted by the piston 68 on the long torque arm 32 after the bar B has returned or "rebounded" from the 1 ¼ in. deflection of the torque arm 32.

With the first phase of the rating test completed, the valve 80 is opened to initiate an optional second phase. The piston 68 rises to its maximum extension of 1 ¼ in., whereupon the set key 36 is removed. Moreover, the valve 80 is closed, and this vents the barrel 66,  
10 causing the piston 68 to descend under the torque exerted by the bar A, to its fully retracted position. Thereupon, the piston 68 is engaged with a tool and rotated to the position in which it will extend only the prescribed amount. Then the valve 80 is again opened and the piston 68 extends the prescribed amount – 1 in. in this instance – which places it in the same position as it assumed in first phase when it retracted with the set key on it. The force  
15 registered on the display 90 is noted and also recorded against the bar B. Even though the bar B in the second phase underwent the same angular displacement as in the first phase, the amount of force exerted on the end of the long torque arm 32 and registered at the display 90 could well differ, with the force exerted upon rebound being less than that exerted absent the rebound. The differences in the two forces are recorded and provide another  
20 measure for comparing different torsion bars B.

Rarely are any torque arms 20 on a vehicle C 12 inches long. Usually they are longer, so the torque is applied at the greater distance from the axis X. This is where

compensating keys 38, matched to the torque arms 20 of vehicles without any mathematical calculations, are used to simulate the spring rates of torsion bars B.